Test Report

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Comparative energy consumption test with different tyres mounted on slurry tanker and contractor's/farm wagon

Ministry of Food, Agriculture and Fisheries
Institute og Agricultural Sciences
Department of Agricultural Engineering

Manufacturers:
Alliance, Michelin and Nokian

Entrants:
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Summary and conclusion

Comparative energy consumption tests were made during transport with a 20 t contractor's/farm wagon and a 20,000 l slurry tanker. Both vehicles were hauled by a Fendt 930 Vario tractor. The analyses were carried out under practical conditions. Road haulage was performed at speeds of 30 and 40 km/h, and field haulage was performed in stubble and on ploughed soil. For field haulage, a speed of 10 km/h was maintained. The applied tyre pressure rates conformed to the load and speed rates stipulated in the respective producers' data.

The results are stated as relative diesel consumption. A mounting consisting of 650/60-30.5/173 A8 Alliance 328 TL diagonal tyres was used as slurry tanker reference. The analysed tyres were 650/65R 30.5/176 D Michelin CARGOXBIB TL, 710/55R 34/169 D Nokian ELS TL and 800/50R 34/168 D Nokian ELS TL. For field haulage all three tyres will provide 10-13 % savings, and for road haulage savings of 14-16 % will be seen.

550/60-22.5/12 PR Alliance 328 TL diagonal tyres were used as reference for the contractor's wagon, and as reference for the analysed tyres, 550/60R 22.5/159 E Alliance 380 TL, 560/60R 22.5/161 D Michelin CARGOXBIB TL and 550/60R 22,5/151 D Nokian ELS TL were used. Compared to the reference tyre, only minor savings were obtained in the cases where 550/60R 22.5/159 E Alliance 380 TL was used, whereas for each of the other two tyres, about 12 % could be saved on field haulage and about 7 % on road haulage.

In connection with the above-mentioned analyses, the ploughland sinkage rate was determined for the slurry tanker. The analyses indicate that sinkage rates of about 8 cm were seen for both 650/60-30.5/175 A8 Alliance 328 TL diagonal tyre (reference tyre) and 710/55R 34/169 D Nokian ELS TL, whereas the for tyres 650/65R 30.5/176 D Michelin CARGOXBIB TL and 800/50R 34/168 D Nokian ELS TL, the sinkage rates were about 2 cm less. The analysis was based on a great number of measurements, but unfortunately, an approved method for the performance of result analyses is not available at present, and therefore, general mean figures are used to indicate the obtained results.

Purpose of test

The purpose of the test has been to determine the relative energy consumption involved with haulage with slurry tanker and contractor's/farm wagon with various tyre mountings (diagonal versus radical). The analyses were made under realistic field and road conditions.

Method and accomplishment of test

For the accomplishment of the test, a 20 t BS contractor's wagon/farm wagon and a 20.000 l BS slurry tanker were used. The vehicles were hauled by a Fendt 930 vario tractor mounted

with 1050/50 R32/178 A8 Michelin MEGAXBIB TL rear tyres and 710/55R 30/153 A8 Michelin MACHXBIB TL front tyres. For both vehicles road tests were performed at speeds of 30 and 40 km/h. The slurry tanker was furthermore analysed for haulage on stubble and newly ploughed soil. The contractor's/farm wagon was analysed on stubble soil. For field haulage, a speed of 10 km/h was used. The tyre pressure rate was determined in relation to the actual load and speed stipulated by the respective producers. The analyses were accomplished under dry conditions and with a limited vehicle sinkage rate on both stubble and ploughland.

The built-in fuel meter of the tractor was used for the test. Prior to the tests, the meter had been calibrated at the laboratory of Research Centre Bygholm. Calibrations were made at loads of 51.1, 102 and 148.6 kW. At 51.1 kW a deviation of + 3.9 % was seen, and at 102 and 148.6 kW deviations below 1.2 % were seen. There have been no reports of error variations over time. Because the test was based on relative measurements, corrections for such relatively small errors were not made. In order to eliminate potential errors, it was attempted to keep a constant fuel tank temperature of about 60^{o}C. During the haulage, the tractor was set at 2200 rpm. and a constant speed (excl. of slip) was kept.

The contractor's wagon/farm wagon was loaded with 16 t base gravel, and as such, the total load on the boogie shaft was 16.02 t. Correspondingly, the slurry tanker was loaded at full capacity with 20 t, corresponding to a total load on the boogie shaft of 26.58 t. The data for tyre mounting and tyre pressure are specified in Table 1.

Table 1. Tyre mounting and tyre pressure during haulage with slurry tanker

Tyre, slurry tanker	Field 10 km/h	Road 30 km/h	Road 40 km/h
650/60-30.5/173 A8 Alliance 328 TL	1.5 Bar	1.8 Bar	2.0 Bar
650/65R 30.5/176 D Michelin CARGOXBIB TL	1.4 Bar	1.8 Bar	2.0 Bar
710/55R 34/169 D Nokian ELS TL	1.6 Bar	2.0 Bar	2.4 Bar
800/50R 34/168 D Nokian ELS TL	1.2 Bar	1.6 Bar	2.0 Bar

Table 2. Tyre mounting and tyre pressure during haulage with contractor's wagon

Tyres, contractor's wagon	Field 10 km/h	Road 30 km/h	Road 40 km/h
550/60-22.5/12 PR Alliance 328 TL	1.3 Bar	1.7 Bar	2.1 Bar
550/60R 22.5/159 E Alliance 380 TL	1.2 Bar	1.5 Bar	1.8 Bar
560/60R 22.5/161 D Michelin CARGOXBIB	1.2 Bar	1.6 Bar	1.8 Bar
550/60R 22,5/151 D Nokian ELS TL	1.6 Bar	2.0 Bar	2.4 Bar

The road haulage was accomplished on an established asphalt road with at total length of 3.7 km. The field haulage sessions were accomplished on a uniform, level field with a clay content of app. 10 % and a topsoil moisture level of 18.2 %, at which conditions the soil will be fit for seed bed preparation. The field was set aside from the time of harvesting and until the tests were performed on 7-8 October 2003. The ploughing took place immediately before the haulage. The field preparations had included light harrowing transversely to the haulage direction of the wagon. For each tyre mounting and field type a total distance of 1.2 km, divided into eight registration intervals, was covered.

In order to perform the variance analysis, a factor model was used for the statistical data analysis. No systematic errors as regards variations in test areas, fuel measurements or the like were seen.

Test result

The results from the analysis are shown in the below tables and figures. Since no relative difference was found between the analysed tyres at either speed, the results obtained for road haulage at 30 and 40 km/h have been compiled. To obtain the best statistical certainty, an overall analysis should be made. For this reason, the results from stubble field and ploughed soil have also been compiled.

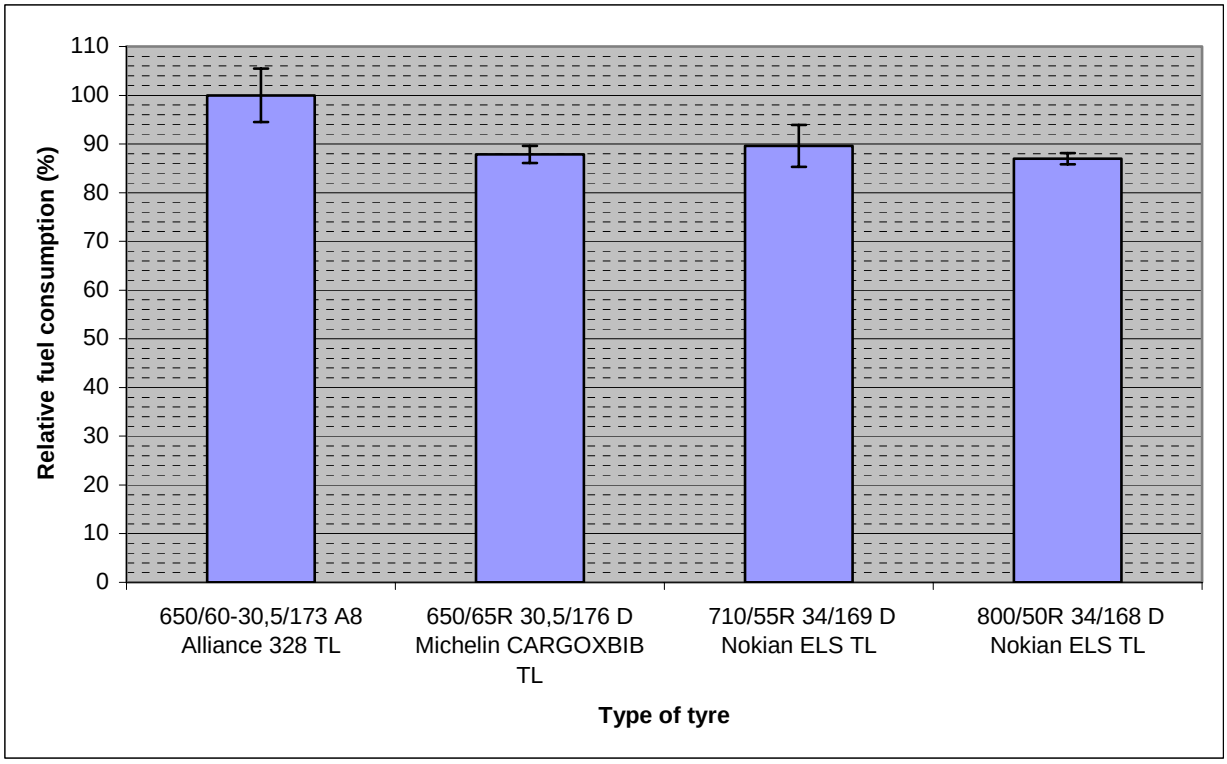

Figure 1. Slurry tanker, field. Relative fuel consumption in relation to haulage with 650/60-30.5/173 A8 Alliance 328 TL diagonal tyres

Table 3. Slurry tanker, field. Relative fuel consumption in relation to haulage with 650/60 30.5/173 A8 Alliance 328 TL diagonal tyres

Tyres	Mean value (%)	95% confidence interval (%)	Difference in relation to reference	Signifi-cance
650/60-30.5/173 A8 Alliance 328 TL	100.0	94.5-105.5	0.0	
650/65R 30.5/176 D Michelin CARGOXBIB TL	87.9	85.5-89.6	-12.1	<0.0001
710/55R 34/169 D Nokian ELS TL	89.6	85.3-93.9	-10.4	0.004
800/50R 34/168 D Nokian ELS TL	87.0	85.8-88.2	-13.0	<0.0001

The statistical analysis for field haulage with slurry tanker shows a significant difference between 650/60-30.5/173 A8 Alliance 328 TL diagonal tyres and the three other tyre types, for which the energy consumption on haulage does not vary significantly.

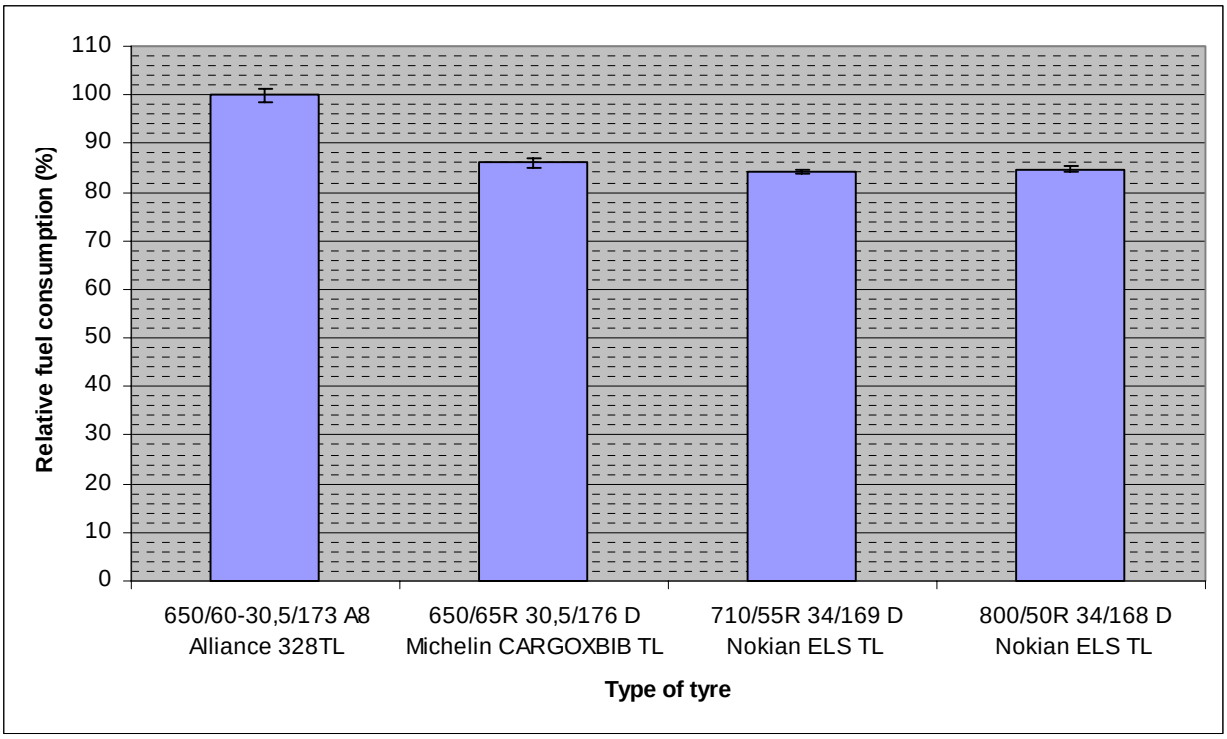

Figure 2. Slurry tanker, road. Relative fuel consumption in relation to haulage with 650/60-30.5/173 A8 Alliance 328 TL diagonal tyres

Table 4. Slurry tanker, road. Relative fuel consumption in relation to haulage with 650/60-30.5/173 A8 Alliance 328 TL diagonal tyres

Tyres	Mean value (%)	95% confidence interval (%)	Difference in relation to reference	Signifi-cance
650/60-30.5/173 A8 Alliance 328 TL	100.0	98.7-101.3	0.0	
650/65R 30.5/176 D Michelin CARGOXBIB TL	86.0	85.1-86.9	-14.0	<0.0001
710/55R 34/169 D Nokian ELS TL	84.1	83.7-84.5	-15.9	<0.0001
800/50R 34/168 D Nokian ELS TL	84.8	84.2-85.4	-15.2	<0.0001

For haulage on road with slurry tanker, the statistical analysis shows that the significantly highest energy consumption will be seen with 650/60-30.5/173 A8 Alliance 328 TL diagonal tyres. Next in line will be the 650/65R 30.5/176 D Michelin CARGOXBIB TL tyre, which shows a significant difference compared to the two tyres 710/55R 34/169 D Nokian ELS TL and 800/50R 34/168 D Nokian ELS TL, the energy consumptions of which are not signifi-cantly different from one another.

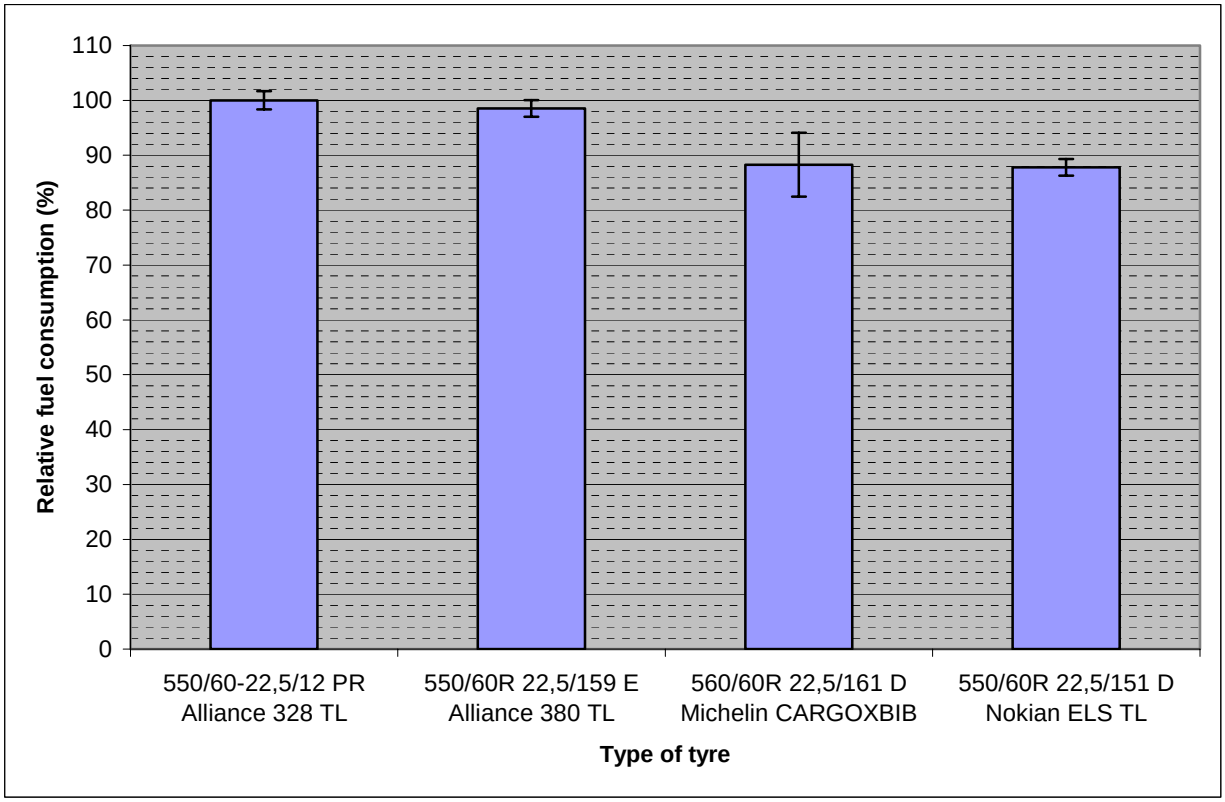

Figure 3. Contractor's/farm wagon, stubble field. Relative fuel consumption in rela tion to haulage with 550/60-22.5/12 PR Alliance 328 TL diagonal tyres

Table 5. Contractor's/farm wagon, stubble field. Relative fuel consumption in relation to haulage with 550/60-22.5/12 PR Alliance 328 TL diagonal tyres

Tyres	Mean value (%)	95% confidence interval (%)	Difference in relation to reference	Signifi-cance
550/60-22.5/12 PR Alliance 328 TL	100.0	98.5-101.5	0.0	
550/60R 22.5/159 E Alliance 380 TL	98.5	96.9-100.2	-1.5	n.s.
560/60R 22.5/161 D Michelin CARGOXBIB TL	88.3	82.5-94.1	-11.7	0.0012
550/60R 22.5/151 D Nokian ELS TL	87.8	86.3-89.3	-12.2	<0.0001

From the result analysis, "haulage on field with contractor's / farm wagon", it will be seen that the significantly highest energy consumption will be found with 550/60-22.5/12 PR Alliance 328 TL diagonal tyres. Next in line will be the 550/60R 22.5/159 E Alliance 380 TL tyre, which will imply a significantly higher energy consumption than the 560/60R 22.5/161 D Michelin CARGOXBIB TL tyre, which does not vary significantly from the 550/60R 22.5/151 D Nokian ELS TL tyre.

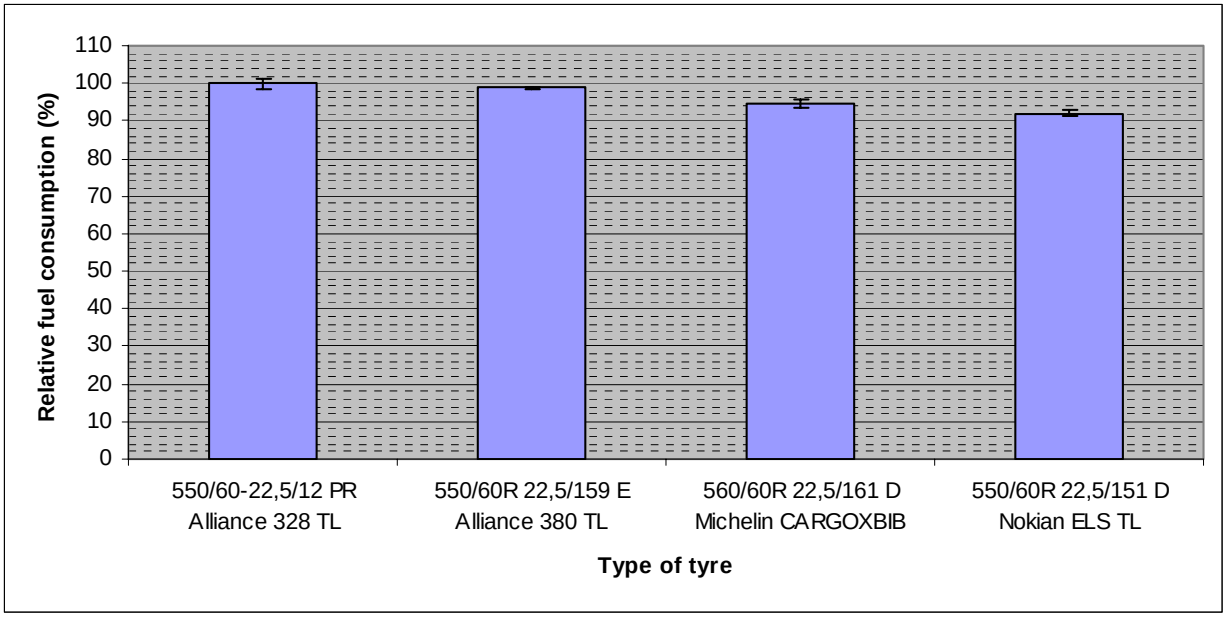

Figure 4. Contractor's/farm wagon, road. Relative fuel consumption in relation to haulage with 550/60-22.5/12 PR Alliance 328 TL diagonal tyres

Table 6. Contractor's/farm wagon , road. Relative fuel consumption in relation to haulage with 550/60-22.5/12 PR Alliance 328 TL diagonal tyres

Tyres	Mean value (%)	95% Confidence interval (%)	Difference in relation to reference	Significance
550/60-22.5/12 PR Alliance 328 TL	100.0	98.7-101.4	20.0	
550/60R 22.5/159 E Alliance 380 TL	98.8	98.5-99.0	-1.2	n.s.
560/60R 22.5/161 D Michelin CARGOXBIB TL	94.6	93.6-95.6	-5.4	0.0001
550/60R 22.5/151 D Nokian ELS TL	92.1	91.3-92.9	-7.9	<0.0001

The result analysis, which included a contractor's/farm wagon prior to haulage on road, shows that the energy consumption involved with the 550/60R 22.5/159 E Alliance 380 TL tyre does not vary significantly from that of the 550/60-225/12 PR Alliance 328 TL diagonal reference tyre. For the other two types of tyre, i.e. 560/60R 22.5/161 D Michelin CARGOXBIB TL and 550/60R 22.5/151 D Nokian ELS TL, highly different energy consumption results than for the reference tyre were obtained. Still, they did not vary significantly from one another.

Depth of track

The sinkage rate is recorded in a profile transversely to the direction of haulage. A frame with a number of thin bars is lowered towards the track profile. To capture the measurement result, a photograph showing the top section of the bars in front of a square grid is taken. The reading will be made manually. Generally, a very small variation, i.e. less than ±0.5 cm, will be seen at the bottom of the profile at a maximum sinkage rate.

Figure 5 shows the general average results obtained from the measurements.

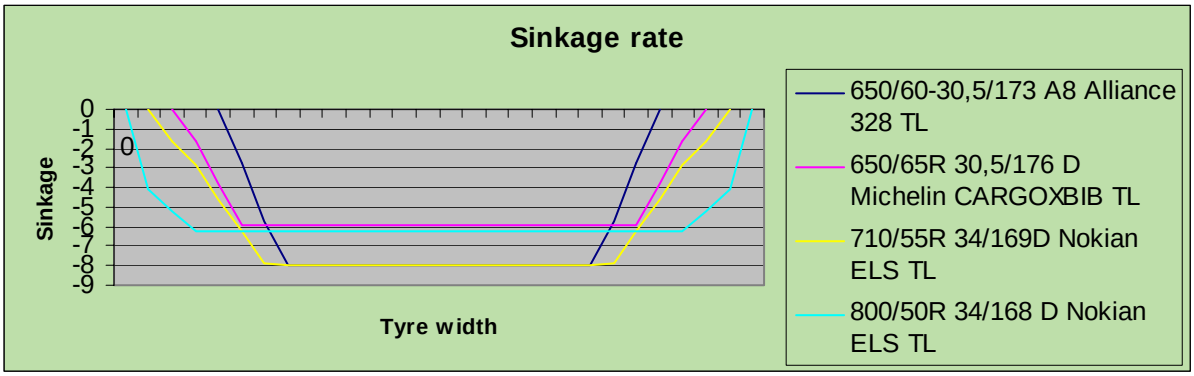

Figure 5. Depth of track recorded during haulage on ploughland using slurry tanker with different tyres

Technical description of the tested vehicles and tyres

650/60-30.5/173 A8 Alliance 328 TL diagonal tyres
550/60-22.5/12 PR Alliance 328 TL diagonal tyres
550/60R 22.5/159 E Allince 380 TL
650/65R 30.5/176 D Michelin CARGOXBIB
560/60R 22.5/161 D Michelin CARGOXBIB
710/55R 34/169 D Nokian ELS TL
800/50R 34/168 D Nokian ELS TL
550/60R 22.5/151 D Nokian ELS TL
BS Contractor's/farm wagon 20 tonnes with BPV "cross" boogie
BS Slurry tanker 20.000 litres with BPV revolving air suspended boogie
Tractor, Fendt 930 vario

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